Introduction to Graphics

Assignment 1: Scanconversion of lines

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1 Problem description

We wish to construct an algorithm that draws a line of pixels from point $(x1, y1)$ to $(x2, y2)$. Unfortuantly the optimal line between these points does not always go through grid vertex's. To combat this we design this algorithm to pick the points closest to the optimal line.

2 Algorithm description

The algorithm creates a new point d on the following column, halfway between the two pixels. The two pixels are called ΔE (The eastern one) and ΔNE (the northeasteren one). To calculate the following point, the line is compared to d, if d is smaller the correct pixel is the northeastern one, otherwise the eastern one is picked. This is then done until the of the line is reached.

2.1 Algorithm edgecases

We have some different edgecases we have to keep in mind while implementing the algorithm:

- Slope above 1
- Slope below 0
- x2 larger then x1

These 3 edgecases gives us a total of 8 diffrent lines that needs to be handled.

2.1.1 Slope above 1

This type of line I will call y-dominant. It is a problem as the base algorithm always will increment the x value, which is not correct when we have a slope above one. It can be handlede by flipping the x and y coordinates of both points, in the algorithm, while not flipping them when drawing the pixels. This makes the algorithm calculate the line from the perspective of y instead of x, and because x has a slope above 1, y will not

```
void FltkDevice::DrawLine(int xstart, int ystart,
                          int xend, int yend) {
    ...
    if (ydom) { //checks if y is dominat and flip values if it is
        this->DrawLineHelper(dy, dx, ystart, xstart, yend, ydom);}
    else {
        this->DrawLineHelper(dx, dy, xstart, ystart, xend, ydom);}


void FltkDevice::DrawLineHelper(int dx,  int dy, int x,   int y,
                                int end, bool ydom) {
        ...
        if(ydom) {SetPixel(y, x, 0);} //draws ydominant pixel
            else {SetPixel(x, y, 0);}
```

2.1.2 Slope below 0

For this to work I need to pick the Southeastern pixel instead of the Northeastern, I need to decrement y instead of incrementing it and when we check 0 ageinst d I have to keep in mind ΔSE should be lower then ΔE.

```
void fltkdevice::drawlinehelper(int dx,  int dy, int x, int y,
                                int end, bool ydom, bool yneg) {
    ...
    if (not yneg) {
        dNE = 2 * (dy - dx); //dNE
        dE  = 2 * dy;
        }
    else {
        ...
        % else {
            dNE = 2 * (dx - dy); //dSE
            dE  = 2 * dy;
        }
    ...
    if (yneg){checkd = (d <= 0);} // Difference between NE and SE calculations
        else {checkd = (d >  0);}
```

Another problem emerges when we have a slope below -1. When my current implementation solves the problem of a slope below 0, it flips the line upside down and uses the algorithm on the now positive slope. This gives us the self contradicting second problem of having to deal with a slope that is both below 0 and above 1. To deal with this i made a small change to the wrapper function that deals with the y domination problems, so that the x and y are not switched.

```
void FltkDevice::DrawLine(int xstart, int ystart,
                          int xend, int yend) {
    ...
    if (ydom) { //checks if y is dominat and flip values if it is
        if (yneg) {
            int t = yend;
            yend = ystart;
            ystart = t;
            t = xend;
            xend = xstart;
            xstart = t;
            }
        this->DrawLineHelper(dy, dx, ystart, xstart, yend, ydom, yneg);}
    else {
        this->DrawLineHelper(dx, dy, xstart, ystart, xend, ydom, yneg);}
```

2.1.3 Negative Δx

With a negative delta value our algorithm would have to draw from right to left, using dW and dSW. Instead of implementing this i used my wrapperfunction to detect this problem by comparing *xstart* and *xend*, and if found swap the my start and end position.

```
    bool xneg = xstart > xend;

    if (xneg) { int t = xstart; xstart = xend; xend = t;
                t = ystart; ystart = yend; yend = t;}
```

3 Implementation

```
void FltkDevice::DrawLine(int xstart, int ystart,
                          int xend, int yend) {
    bool xneg = xstart > xend;

    if (xneg) { int t = xstart; xstart = xend; xend = t;
                t = ystart; ystart = yend; yend = t;}

    bool yneg = ystart > yend;
    int dx  = xend - xstart;
    int dy  = yend - ystart;

    bool ydom = std::abs(dy) > std::abs(dx);

    if (ydom) { //checks if y is dominat and flip values if it is
        if (yneg) {
            int t = yend;
            yend = ystart;
            ystart = t;
            t = xend;
            xend = xstart;
            xstart = t;
            }
        this->DrawLineHelper(dy, dx, ystart, xstart, yend, ydom, yneg);}
    else {
        this->DrawLineHelper(dx, dy, xstart, ystart, xend, ydom, yneg);}
}
```

```
void FltkDevice::DrawLineHelper(int dx,  int dy, int x, int y,
                                int end, bool ydom, bool yneg) {
    int dNE,dE;
    bool checkd;
    int d   = 2 * dy - dx;

    if (not yneg) {
        dNE = 2 * (dy - dx); //dNE
        dE  = 2 * dy;
        }
    else {
        if (ydom){
            dNE = 2 * (dy - dx); //dSE
            dE  = 2 * dx;
        }
        else {
            dNE = 2 * (dx - dy); //dSE
            dE  = 2 * dy;
        }
    }

    while (x <= end) {
        if (ydom){SetPixel(y, x, 0);} // Draws ydominant pixel
            else {SetPixel(x, y, 0);}

        if (yneg){checkd = (d <= 0);} // Difference between NE and SE calculations
            else {checkd = (d >  0);}

        if (checkd) {// Pick the NorthEast Cornor
            if (yneg){ y--;}
               else  { y++;}
        d =+ dNE;
        }
        else {
            d = d + dE;
            }
        x++;
        }
    this->Update();
    this->UnitLength(this->UnitLength(50));
}
```

4 Testing

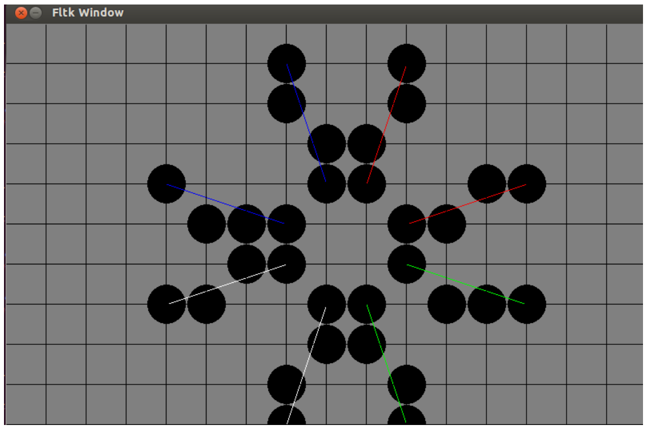
The test is generated by the following code:

```
this-> TestLine(10,5,13,6, 1.0,0.0,0.0);
this-> DrawLine(10,5,13,6);
this-> TestLine(9,6,10,9, 1.0,0.0,0.0);
this-> DrawLine(9,6,10,9); //red

this-> TestLine(10,4,13,3, 0.0,1.0,0.0);
this-> DrawLine(10,4,13,3);
this-> TestLine(9,3,10,0, 0.0,1.0,0.0);
this-> DrawLine(9,3,10,0); //green

this-> TestLine(7,4,4,3, 1.0,1.0,1.0);
this-> DrawLine(7,4,4,3);
this-> TestLine(8,3,7,0, 1.0,1.0,1.0);
this-> DrawLine(8,3,7,0); //white

this-> TestLine(7,5,4,6, 0.0,0.0,1.0);
this-> DrawLine(7,5,4,6);
this-> TestLine(8,6,7,9, 0.0,0.0,1.0);
this-> DrawLine(8,6,7,9); //blue
```



As the graphic shows most of the lines works as inteded. With the exceptions of the one with a negative slope (flat green) and its sisterline the flat blue. I suspect this error comes from me not finding the correct value for ΔSE.

4.1 Code

The code for the implementation can be found in the zipped file fltkdotdevice, and can be run with button 2.